Three Town BMP Development Project
2009-12/ARRA 604

Prepared For
Mass Department of Environmental Protection
Town of Sharon, MA
Town of Stoughton, MA
Town of Walpole, MA

Prepared By
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Executive Summary

The goal of this project was to identify at least three locations in the Towns of Sharon, Stoughton and Walpole that are suitable for retrofitting with structural stormwater Best Management Practices (BMPs). Secondary project goals were to create a methodology to efficiently survey a wide geographic area and capture data in the field in order to prioritize potential opportunities to implement stormwater BMPs and to use the data collected to support preliminary designs for the top three identified locations including estimates of the operation and maintenance costs for the top 10 locations.

This project emphasized a visual survey of the BMP retrofit potential of Sites using ArcPad software as the main data collection tool. Determination of the ease of BMP implementation, likelihood for acceptance from key abutters, type of BMP recommended for the site, approximate size of the contributing drainage area and possible implementation conflicts were the primary criteria for data collected during the survey portion of the project. ArcPad software allowed for improved data collection by getting all data into a GIS compatible format in the field. A personal geodatabase was created for each Town that included separate layers for Sites, Drainage Areas, BMP recommendations, Projects and Discharge Points. Each of these layers had a number of data fields that were populated in a manner similar to a paper field sheet.

Using this new survey format, the project was able to evaluate more than 20 potential retrofit locations in each of the three towns. Thesesites were prioritized down to a list of the top ten opportunities in each town. Project partners the Neponset River Watershed Association (the Association), Comprehensive Environmental Inc. (CEI) and the applicable town Engineering, Conservation and DPW staff then visited each of the top ten locations to further prioritize potential locations culminating in the selection of the top three sites. Criteria such as ease of implementation, overall drainage area size, type of BMP, potential operation and maintenance cost, public education value, and aestheticswere all used in narrowing the list of sites down to the best three options in each town.

Two rounds of wet weather water quality sampling were conducted at each of the top three locations to further illustrate the need for improvements at these locations. Water samples were taken at the outfall of each drainage system where a BMP was proposed, as well as from the receiving water for that drainage system. Every attempt was made to take samples during the "first flush" of the drainage system, though due to time constraints and the vagaries of the weather not all sampling events occurred during first flush conditions. Since the Neponset River watershed has a TMDL for bacteria, the primary pollutant of concern, and the primary focus of the sampling effort, was pathogens, specifically *E.coli* bacteria. In addition, samples were analyzed for temperature, ammonia and surfactants. As anticipated, the data from these water samples show a need for improved stormwater treatment at nearly all of the sampling locations . Water quality data show that only 3 out of 14 outfalls or discharge points sampled had bacteria levels below the Massachusetts water quality standard for bacteria (<235)(Table 5). Similarly all but two of the receiving waters failed to meet water quality standards for bacteria, indicating a clear need for improved stormwater quality at these locations (Table 6).

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Disclaimer and Acknowledgement of Support

This project has been financed partially with American Recovery and Reinvestment Act Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under Section 604(b) of the Clean Water Act. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Additional support, data, leadership and in-kind funding was generously provided by the staff of the Sharon, Walpole and Stoughton Engineering Departments and Departments of Public Work, as well as the staff of the Walpole Conservation Commission. Further in-kind funding was provided by the Neponset River Watershed Association.

Special thanks the Sharon Department of Public Works for serving as the fiscal agent for this regional effort.

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Introduction

The Sharon, Stoughton and Walpole Departments of Public Works partnered with each other and the Neponset River Watershed Association (the Association) and Comprehensive Environmental Inc. (CEI) to identify sites suitable for retrofitting with structural stormwater Best Management Practices (BMPs) and to develop conceptual designs for BMPs at those sites.

The specific goals of the project were to:

- Identify at least three sites (neighborhoods or discrete collection areas) that are amenable to the implementation of structural BMP retrofits in each of the three towns.
- Prepare conceptual designs and cost estimates to support future applications for implementation funding.
- Demonstrate a methodology which can be used to efficiently identify and prioritize stormwater BMP retrofit opportunities in other towns and other watersheds in the future.

The project was conducted in the Towns of Sharon Stoughton and Walpole (Fig. 1). The approach for this project was based on lessons learned from past BMP development efforts by The Association. These past efforts utilized a program of intensive, wet-weather outfall testing applied to a relatively small geographic area, in an effort to prioritize stormwater retrofit sites. The sampling effort was followed by the development of conceptual BMP designs as well as efforts to secure abutter approval for implementation of the BMPs.

Based on this prior experience, a new approach to identifying, prioritizing and designing BMP retrofits was devised. This new approach emphasized covering a very large geographic area using a visual survey along with in the field digitization of data in the form of a Geographic Information System, or GIS. This allowed for BMP retrofit potential to be rapidly evaluated across a large area, to prioritize retrofit opportunities and at the same time take into account probable ease of implementation, engineering feasibility, potential for pollutant load reduction and the likelihood for acceptance by abutters. Once this broad assessment of opportunities was completed and vetted with key internal and external stakeholders, the relatively expensive tasks of final conceptual design and quantification of pollutant loading took place.

First, a list of preferred BMPs was developed and reviewed with each town. The list was initially adapted from current available literature from the Massachusetts Department of Environmental Protection, Vermont Department of Natural Resources and the Center for Watershed Protection (CWP 2007, MADEP 2008, VNR 2002). The list of available BMPs was further prioritized based on review and discussion amongst each town’s DPW and/or Engineering Department, the Watershed Association, the Town’s Conservation Commission, CEI, and other interested parties. The criteria for the list of preferred BMPs included their ability to achieve effective levels of pollutant load reduction for the pollutants of concern (bacteria, nutrients, sediment) and compatibility with operational, aesthetic and maintenance requirements in each town. The purpose of this step was not to reinvent available BMP design guides, but rather to ensure that the needs of all key internal stakeholders were fully understood “up-front.”

The next step was to assemble existing information on the drainage systems of all three towns, quantitative information such as maps of drainage systems and town-owned land, along with programmatic information such as plans for drainage or roadway work with which a stormwater component might be efficiently dovetailed, and anecdotal information such as existing drainage problem-areas were compiled. GIS data layers were also obtained from all three towns. This data included layers identifying individual land parcels, town owned properties, stormwater drainage and infrastructure, edge of pavement, road right of ways, and in some instances other available information on easements and potential conflicting utilities (Appendix 3a, see compact disc). Additional GIS layers were obtained from Mass GIS, including orthophotos of the study areas and hydrography (Appendix 3a, see compact disc). Finally, data from the Natural Resource Conservation Service (NRCS) was obtained outlining major hydrologic soil groups within the study areas (Appendix 3a, see compact disc).

Once this information was compiled and integrated into the GIS the “BMP retrofit feasibility field survey” was then performed by first converting the desktop GIS into a mobile format using ArcPad software. Then a visual survey of drainage outfalls and collection areas was performed by Watershed Association staff to compile a preliminary rating of retrofit feasibility and potentially appropriate BMPs for sites. Data was captured in the field using ArcPad software installed onto a tablet PC notebook computer. This enabled the surveyor to input data in real time and helped to make the prioritization process more efficient by eliminating the need to transfer data from multiple paper field sheets to a more useable digital format. In addition to the increased efficiency of imputing the data directly to a digital format, the geodatabase allowed for rough calculation of drainage area size and available space for individual BMPs in the field. By using tools integrated in the ArcPad software, Association staff were able to obtain a more accurate estimate of available space for particular BMPs and how that space related to the estimated size of individual drainage areas allowing for a better initial prioritization of BMP recommendations.

Once the survey was completed site visits were conducted at the top 10 prioritized locations in each town by a team including Watershed Association staff, CEI and the applicable Engineering, DPW and Conservation Commission staff. Based on the site visits by the project team, a “draft final” list of 10 retrofit opportunities per town was prepared with each opportunity ranked from one to ten (Tables 1-3,).

Once the top 10 sites for each town were identified, Watershed Association staff collected water quality samples at each of the top three sites per town (two rounds of wet weather sampling for bacteria, ammonia, surfactants and temperature) in accordance with the Association’s DEP/EPA-approved QAPP (Appendix 2a,b, Figs. 5-15). Note that while this project is based in part on the premise that pollutant loading can be reasonably well estimated through a visual survey, experience has shown that when it comes time to actually ask residents or funders to move forward, it is essential to have some quantitative data to document the need for action.

After the top ten sites for each town were agreed upon, the project engineering consultant prepared conceptual designs for the top three locations, detailed cost estimates for the top three locations along with more limited cost estimates and operation and maintenance requirements for all ten (Appendix 6a-d).

Project Approach

For this project a step by step process was created starting with defining a list of preferable BMPs. Additional steps included getting information about individual town infrastructure and potential upcoming construction projects or drainage area problems, an desktop survey of potential locations, field surveying to identify and prioritize potential retrofit opportunities, further prioritization of retrofit opportunities using agreed upon criteria between stakeholders and finally culminated with preliminary design and cost estimates produced for the top three locations in each town.

The first step was to come up with a list of BMPs that all three project partners could agree upon for potential retrofit locations. This list was compiled through collaboration between the Association and CEI and was later vetted with each town to discern which practices were more acceptable than others (Table 4, Appendix 1i-k). All three towns were consistent in favoring those practices that required the least amount of operation and maintenance and were surface structures. Conversely, all three towns also agreed that the least desirable practices were underground structures, either infiltrators or filters, or those that had unique maintenance requirements which the town felt were beyond their current capabilities, such as porous pavement. Criteria used to determine acceptable BMPs for each town included the cost of implementation, operation and maintenance schedules, pollutant removal efficiency and aesthetic criteria. The only BMPs that were taken out of consideration were swales since since some literature has suggested that they are not effective at removing bacteria and in some cases can actually increase bacteria loading (Clary et. al. 2008).

Following seperate meetings between the Association, CEI and each of the three towns a loosely prioritized list of possible BMPs was agreed upon that would later be used in the field to further prioritize sites for retrofit potential. Interestingly all three towns agreed on the same prioritization of potential BMP choices. In addition to creating a list of preferred BMPs these meetings were also used as a forum to discuss any future development projects or problem drainage areas as well as collect information on town owned property, current drainage infrastructure and other utility information (Table 4, Appendix 1i-k, Appendix 3a, see compact disc).

Once the list of preferred BMPs for each town was finalized, a digital field database was created using ArcPad software to allow for real time data collection (Appendix 4a, see compact disc). The database included layers for Sites, Drainage Areas, BMPs, Discharge Points and also a layer to combine Sites into individual Projects when appropriate (Appendix 4a, see compact disc).

Each layer of the database was designed to capture certain key information related to a different type of geographic feature. For the Site layer, attributes included initial survey date, site name, priority and remarks about the site in general. This layer was primarily used to prioritize and track areas for the field visits based on a desktop analysis of retrofit potential.

The Drainage Area layer was created to define the contributing drainage area to a recommended BMP or outfall. Attributes for this layer included Site ID, Project ID, Land Use, Existing BMPs, BMPs Sufficient, Underground Only, and Outfall ID. For each drainage area outlined, a unique ID was created in ArcPad automatically which was used as the official ID number for that particular drainage area. Site ID and Project ID attributes were used to relate the drainage area layer to the Site and Project layers of the database. The other data fields were created to capture data about the land use within the drainage area, whether or not there were already BMPs located within the drainage area and if they were sufficient to treat the stormwater at that location.

The main project layer created for this project was the BMP layer of the field database. This layer included fields for the following attributes: Site ID, Drainage Area ID, Existing BMPs, Location Type, BMP Type 1, BMP Type 2, Soils, Constraint 1, Constraint 2, Constraint 3, Owner Type, Abutting Use, Abutter Conflict, Overall Rating and Remarks. Similar to the Drainage Area layer the BMP layer had a unique numerical ID created each time a BMP was outlined. The Site ID and Drainage Area ID attributes were included to relate each individual BMP with a specific Site and Drainage Area. Two separate attributes were included for BMP recommendations (BMP Type 1 and 2). Three separate attributes were included to denote potential conflicts that may have been apparent at the location where the BMP would be located. Additionally, attributes were included for what the abutting land use appeared to be and estimate the likliehood of conflicts with abutters if implementation of the BMP were to go forward. Criteria used to determine potential conflict with abutters was qualitative and was driven by past experience. Essentially, the more individual private land owners in an area proposed for retrofitting and the more visually intrusive the BMP, the greater the likelihood for conflicts with abutters. For example, a residential neighborhood where the proposed BMP would require an easement for implementation would be considered a high risk for conflicts whereas a retrofit located in a residential neighborhood but the practice would be entirely on Town owned property would be considered as a moderate. Finally there were attributes to give a first impression of the priority of the site (Overall Rating) relative to the ease of implementation and any other remarks that might have been worth noting (Remarks).

The Discharge Point layer of the field database was created to identify outfalls or other types of discharge points that were not otherwise mapped or available in the town's digital format. Also, the Project layer of the database was created to allow regrouping of Sites, BMPs and Drainage Areas together that made more sense as one combined project rather than individual projects.

In addition to the field database, basemaps for each town were created using ArcMap software. Primary layers in each basemap were drawn from MassGIS and included available ortho-imagery, town boundaries, hydrologic soil units, and layers depicting major rivers, tributaries and surface waters.

In addition to the standard layers, the Town of Sharon also made available layers delineating stormwater drainage throughout the town, including layers depicting the placement of outfalls, manholes, catch basins and pipe connectivity. Additional layers from the town showed the placement of both public and private wells within the town. Finally Sharon included parcel layers for both Town owned property, the Trustees of Reservations and Audubon Society and parcel data for individually owned property (Appendix 3a, see compact disc).

The Town of Walpole made available additional layers delineating stormwater drainage throughout the town as well. Layers included information for outfalls, catchbasins, manholes and overall drainage connectivity. Additionally, Walpole included data layers depicting sewer lines and their connectivity, sewer manholes, hydrant laterals, water mains and property parcels. The parcel layer was further broken down with an additional layer for all town owned parcels (Appendix 3a, see compact disc).

Stoughton also provided additional GIS data layers for public and private property, outfalls, and some drainage structures (Appendix 3a, see compact disc). Layers showing connectivity of the stormwater drainage system with the locations for catch basins and manholes were not available digitally. Field surveys by the Association attempted to locate all likely connected catchbasins and overall drainage area size in the field. In some instances there were paper plans available to aid in creating the preliminary designs and cost estimates for certain retrofits.

Once the geodatabase was finalized for each town, field surveys were conducted in two parts. An initial desktop survey of potential sites was conducted using ArcMap software in the office. These sites were initially prioritized so that areas adjacent to or fully within town owned property were given the highest priority for actual field investigation.

Once the Sites layer was created and prioritized, the field survey was conducted for each town (Figs. 2-4). Field investigations involved inspection of individual sites, outlining potential drainage areas and outlining areas with sufficient space to construct BMPs. Over 20 sites were prioritized and visited in each town. Further prioritization of the top 20 sites led to individual site investigations conducted by Association staff, Town Engineering and DPW staff and CEI to produce a final prioritized list of the best 10 locations (Tables 1-3,). The top three locations were then taken by CEI in order to produce preliminary designs and cost estimates for those locations (Figs. 5-15).

While the consulting engineer was creating designs and cost estimates, water quality sampling was conducted at the top three locations. Two rounds of sampling were conducted during wet weather. Samples were analyzed for bacteria, ammonia, surfactants and temperature (Tables 5-6). Samples were taken both from the outfall of the drainage area where BMPs were being proposed as well as the receiving water body in an effort to further illustrate the need for BMPs at these locations.

Each of the three towns placed a high priority on choosing town owned sites. Thus, permission to go forward with preliminary designs and cost estimates was kept within the Engineering and DPW departments making it unnecessary to have meetings to gauge interest and gain approval from individual home owners or property owners.

Upon completion of the project, each town received a geodatabase outlining the potential for stormwater BMP implementation at over 20 different locations (Appendix 3a). In addition, each town received a prioritized list of the top 10 sites with cost estimates and preliminary designs for the top three locations (Appendix 6a-d). Along with this information, water quality data exists for the top three locations per town illustrating the need for BMP implementation at those locations should further permission need to be gained from Town Boards of Selectmen or through the Town meeting process (Tables 5-6). Finally, each town will have an outline of methodology in place and the digital resources created for this project to continue the survey and prioritize further locations for BMPs outside of those areas already surveyed under this project.

Results

At the onset of the project, a list of preferred BMPs was created and agreed upon between Association staff, Town Engineering and DPW departments and CEI (Table 4, Appendix 1l-m). This list was derived from available literature and was not meant to be an exhaustive list of all available BMPs but rather a list of BMPs that all members of the project team felt comfortable with as recommendations going forward.

BMPs were loosely prioritized by overall cost, operation and maintenance requirements and their effectiveness in treating pollutants of concern, specifically pathogens. For this project BMPs such as bioretention cells, infiltration basins and rain gardens ranked higher on the list whereas underground infiltration and filter chambers and porous pavement BMPs were given the lowest priority (Table 4, Appendix 1l-m).

This list of preferred BMPs was then incorporated into the field database for on site prioritization of BMP recommendations (Appendix 4a, see compact disc). The field database was separated into five layers in a GIS (Site, Drainage Area, BMP, Discharge Point and Project) and exported into an ArcPad format.

In the Town of Sharon five BMPs had an overall rating of "Excellent" and nine other BMP recommendations had an overall rating of "Good" (Appendix 4e-f). In the Town of Walpole 12 BMPs hand an overall rating of "Excellent" at seven different Sites. An additional 22 BMP recommendations had an overall rating of "Good" (Appendix 4i-j). In the Town of Stoughton seven BMPs were given an overall rating of "Excellent" with an additional 10 given a rating of "Good" (Appendix 4e-f).

In the Town of Sharon the top 10 locations were Sites 1, 6, 7, 9, 10, 11, 14, 19, 20 and 28 with the top three locations Sites 6, 20 and 9 respectively (Table 1, Figs. 5-7). All BMPs recommended at the top three locations in Sharon received either an "Excellent" or "Good" rating during initial prioritization (Appendix 4e-f). The top 10 locations in the Town of Walpole were Sites 1, 4, 9, 12, 13, 14, 21, 29, 33 and 46 with the top three sites being Sites 4, 21 and 12 respectively (Table 2, Figs. 8-10). The top 10 locations in Stoughton were Sites 7, 10, 11, 12, 13, 15, 16, 17, 19 and 21 with the top three locations Sites 7, 11 and 12 combined and Site 10 (Table 3, Figs. 11-15). All BMPs included in the top locations chosen for Stoughton except one were given an overall rating of "Excellent" (Appendix 4m-n).

Water sampling at the top three locations in Sharon and Walpole was completed on 5/4/11 and 5/19/11. Sampling at the top three sites in Stoughton was conducted on 6/9/11 and 6/22/11. The primary pollutant of concern was bacteria due to the fact that the Neponset River watershed has a TMDL for pathogens. The maximum level of bacteria found at any of the outfalls sampled was >24,196.0 MPN and the minimum was 22.3 MPN (Table 5). The average level of bacteria found at outfalls during sampling was 2,313.2 MPN (Table 5). For receiving waters, the maximum level of bacteria was 12,033 MPN and the minimum was 13.5 MPN (Table 6). The average level of bacteria found in the receiving waters at the top three locations was 1,492.4.0 MPN (Table 6).

Samples were also analyzed for ammonia, surfactants and temperature. The maximum level of ammonia found in any of the outfall samples was 2.229 mg/L and the minimum was 0.000 mg/L

(Table 5). The average ammonia concentration for outfalls was 0.422 mg/L (Table 5). For receiving waters the maximum level of ammonia was found to be 1.501 mg/L and the minimum level found was 0.000 mg/L (Table 6). The average concentration for ammonia found in receiving waters was 0.208 mg/L (Table 6).

Samples from outfalls analyzed for surfactants had a maximum level of 0.50 mg/L and a minimum level of 0.00 mg.L (Table 5). The average level of surfactants found at outfalls was 0.15 mg/L (Table 5). Samples taken from receiving waters at the top three locations showed a maximum level of surfactants to be 0.50 mg/L and a minimum level of 0.00 mg/L (Table 6). The average concentration of surfactants found in receiving waters was 0.06 mg/L (Table 6).

Temperature measured at outfalls ranged from 25.0^{o}C to a minimum of 12.0^{o}C (Table 5). Temperature taken at receiving water locations had a maximum level of 21.0^{o}C and minimum level of 12.5^{o}C (Table 6). The average temperature for both outfalls and receiving waters was 16.6^{o}C (Tables 5-6).

Lessons Learned

The majority of the lessons learned from this project have to do with the creation and implementation of the field database. Several different electronic devices were field tested in an attempt to find a relatively inexpensive device that still had the capabilities necessary to complete the survey effectively and efficiently.

Originally it was thought that a “smartphone” could be used that had a compatible operating system with ArcPad. The thought was that the smartphone would have the ability to be small, had a better resolution screen than other devices and would have the ability to take pictures and have them instantly embedded in the attribute table along with the other data taken in the field. In the end the phone had multiple issues with processor speed and constant crashing of the ArcPad software that made the database almost unusable in the field.

The second device that was field tested was a handheld “palm” device. This device had a more powerful operating system and memory that we believed would help to eliminate the slow speed of the previous device as well as eliminate the issue of the software crashing every few minutes. Unlike the phone the palm device did not have the camera capability but this benefit was somewhat ancillary to the benefits of properly working software. Similar to the phone however, the palm device experienced problems with the software crashing that made the device undesirable as a long term solution for this project. While the palm device did meet the requirements to run the software the processor speed was also not capable of efficient use in the field. Data would take extremely long to load and manipulating the map in the field would further bog the device down making even simple tasks and data entry take long periods of time in the field.

What was eventually settled on was a tablet PC. This device had vastly superior processor speed and memory to either the smartphone or the palm device. The tablet could run with ArcMap and ArcPad software simultaneously and inputting data into the field database was both efficient but more accurate because the map and attributes could be better manipulated in the field. The major drawback to the tablet though was poor visibility of the screen in bright conditions. Typically though some shaded areas could be located at any of the sites that were visited in order to see the screen better and enter data in the field.

The tablet was settled upon prior to the introduction of alternative tablet options such as the Motorola Zoom or similar products like the iPad or iPad 2 having compatibility with the ESRI software used for this project. Now that these products exist and some of the compatibility issues have been addressed by ESRI it is very likely that a better computing solution exists for data acquisition in the field.

Project Summary

This project was able to identify multiple opportunities for stormwater retrofits in each of the surveyed towns. In Sharon the three sites chosen as the best opportunities were Billings St., Brook Rd. and Hixon Farm (Table 1). Each site presented unique opportunities as well as limitations when determining the best possible solution to achieve the greatest pollutant removal efficiency.

At the Billings St. site there did appear to be room within a small wooded section along the roadside where a BMP could be placed (Fig. 5). BMPs initially recommended for this location were a bioretention cell with an underdrain since soils in the area appeared to be of poor infiltrating quality (Appendix 4e-f). A pocket wetland system was also selected as an alternative BMP for this location. After consultation with the Town and CEI it was determined that an extended detention wetland system would be the best option for this location. The conceptual design for this site allows for treatment of over 1” of WQv and an approximate 60% removal efficiency for bacteria per year (Table 7, Appendix 6a). In addition to the pollutant removal efficiency the aesthetics of the site was a key criteria in determining that the extended wetland system would be the best choice for this site. The site is adjacent to Mann’s Pond and also has a parking area with walking trails around the pond. It was important to have the practice look as natural as possible in keeping with the current aesthetic on site.

The site given the second highest priority in Sharon was the Brook Rd. site (Fig. 6). Water quality data at this site did indicate that bacteria levels exceeded the Massachusetts water quality standard for *E.coli* bacteria. Sediments washed through the catchment system as well as down the road itself were also determined to be a key pollutant of concern at this location. Initial survey recommendations for BMPs at this site included bioretention with an underdrain feature or a pocket wetland system (Appendix 4e-f). The practice ultimately chosen for this location was a pocket wetland with a large sediment forebay. This BMP would be sized to accommodate over 1” of annual WQv. This practice would have a 60% removal efficiency for bacteria but also an 80% removal efficiency for TSS (Table 7, Appendix 6a). It is estimated that this feature would remove approximately 2,355 lbs. of TSS annually (Appendix 6a).

The third site chosen for preliminary conceptual designs in Sharon was the Hixon Farm site (Fig. 7). This site is predominately a multifamily housing development. There were no BMPs identified on site during initial investigations. It was proposed during the initial survey that a bioretention cell with an underdrain or a gravel wetland would be the best choices for this location (Appendix 4e-f). During the initial survey there were concerns that depth to ground water would be a significant issue at this location as well as poor soils for infiltration practices.

Ultimately the practice chosen for this site was a bioretention cell with an underdrain. It was determined during site visits that the available space would not accommodate a gravel wetland and that the aesthetic of a bioretention cell might be seen as a benefit at this location. This practice would have 70% removal efficiency for bacteria as well as a 90% TSS removal efficiency (Appendix 6a).

In Walpole the three sites chosen as the top opportunities were the Police/Fire parking lot, the Fisher School and the Johnson Middle School (Table 2). The top site prioritized from this survey was the parking lot behind the Police and Fire departments in the town center (Fig. 8). This location created a unique opportunity to not only treat stormwater but to also enhance the visual aesthetic of the parking area as well. Initial BMP recommendations for this site were bioretention cells designed in series with underdrains to the on site infrastructure (Appendix 4i-j). Site visits conducted by the project partners agreed with this assessment as long as the cells could be designed to treat an adequate WQv and the loss of current parking would be minimized as much as possible. The conceptual design for this site utilizes the benefits of bioretention cells in several areas of the parking lot connected by infiltrating trenches or swales to help convey runoff to the actual treatment practices (Appendix 6b). In addition to the bioretention cells and infiltration conveyances a geoblock vegetation buffer is also being proposed surrounding the box culvert inlet at the North end of the lot to further protect untreated flows from reaching the brook (Appendix 6b). While the current concept is only sized to treat roughly 32% of the annual 1" WQv it was concluded that treatment at this location was necessary due to water quality data and an improved aesthetic to the lot would help to enhance the downtown area. Additionally this site was chosen for its visibility in town making this an excellent location for a demonstration project to help educate citizens about the need for such structures.

The second site chosen in Walpole was at the Fisher Elementary School (Fig. 9). This site presented opportunities on several levels. First, there are several outfalls that discharge to Cobb's Pond located on premises, some mapped digitally by the town and some discovered during the initial site survey (Fig. 9). The potential was there to treat flows from several different discharge points significantly decreasing the overall pollutant load to Cobb's Pond. Additionally, because this site was an elementary school, the opportunity to educate students about BMPs and stormwater pollution also presented itself. At the three outfall locations, pocket wetlands and bioretention cells with underdrains were proposed (Appendix 4i-j). Separation to groundwater was one of the biggest concerns when recommending treatment practices at these locations. Ultimately pocket wetlands were decided on as the best options for two of the outfalls and at the outfall with the largest drainage area an extended detention wetland was proposed (Appendix 6b). In each case there was available space to size the practice to capture the annual 1" WQv or better (Appendix 6b). This site would benefit from a removal of approximately 19,000 lbs. of TSS, 8.7 lbs. of Total Phosphorous, 58 lbs. of Total Nitrogen annually by the proposed wetland treatment practices (Appendix 6b).

The third site chosen in Walpole was at the Johnson Middle School (Fig. 10). At this location there were two main drainage areas to be treated with BMPs (Fig. 10). The initial survey of the two sites recommended either bioretention cells or infiltrations as the best options for treatment (Appendix 4i-j). The larger of the two drainage areas it was decided could be treated with an infiltration basin and the smaller drainage area to the south would be treated with a bioretention cell with underdrains (Table 7, Appendix 6b). The infiltration basin was able to be sized to treat roughly 74% of the annual 1” WQv and the smaller bioretention cell would be able to treat well over 100% of the 1” WQv (Table 7).

The top three sites chosen for retrofitting in Stoughton included the Hanson School, Gibbons School and Mark’s Field (Figs. 11-15). The top site decided on was the Hanson School (Table 3). At this site there were 3 separate BMPs that were able to be recommended within catchment area (Figs. 11-12). The initial survey of the site recommended a bioretention cells or infiltration basins at the two largest areas available for retrofitting and a smaller treebox structure at third location within the catchment area (Figs11-12, Appendix 4m-n). Final BMP recommendations from CEI at these locations replaced the treebox recommended at Site 3 with a small infiltration trench, an infiltration trench at Site 2 and a bioretention cell with underdrains at Site 1 (Appendix 6c). The bioretention cell was sized to treat roughly 78% of the contributing drainage area, the largest infiltration trench would be able to treat approximately 48% of the drainage area and the small infiltration trench would be able to accommodate almost 35% of the drainage area (Table 7, Appendix 6c).

The second site chosen for conceptual designs and cost estimates was actually a combination of two individual sites from the initial survey, the Gibbons School and the Morton St. sites (Figs. 13-14). This site, like the Hanson School site, had opportunities to implement multiple BMPs. The BMPs eventually decided on for these locations were an infiltration basin at the site directly behind the school and playground, a bioretention cell with underdrains treating the parking lot in front of the school and two smaller bioretention cells along Morton St. (Appendix 6c). These BMPs would be able to capture approximately 106%, 115% and 35% of the 1” WQv respectively (Table 7, Appendix 6c).

The final site selected in Stoughton was at Mark’s Field (Fig. 15). This location has no formal drainage system installed. The discharge point does empty into a wetland area however which was a key criterion in deciding on this site as one of the top three. Additionally it was learned while doing post survey site visits that the ball field at this location is being looked at for renovation in the near future which also helped to increase the priority of this site over others in Stoughton. The initial survey of the site recommended a bioretention cell or pocket wetland at this location depending on separation to ground water (Appendix 4m-n). The eventual design that was decided on for this location after the post survey site visit was to recommend an infiltration basin with a graded shoulder to direct flows to the practice (Table 7, Appendix 6c). This practice would be able to treat roughly 108% of the contributing drainage area.

Overall, while the project was in some respects more challenging than anticipated, we were nonetheless able to exceed the deliverables required under the project scope of services both in terms of the number of potential BMP sites evaluated and in the development and testing of a successful model for “direct to digital” data collection which will be of considerable benefit to other similar efforts in the future.

The original intention behind the project proposal had been to use the conceptual designs as the basis for preparing applications to the Section 319 program for construction and implementation funding. Unfortunately, since the original project funding application was submitted, the USEPA has decided that any stormwater improvement project necessary to attain water quality standards in a community that will be covered by the next generation of MS4 permits, is not eligible for 319 funding.

Thus, the next step for the project partners will be to begin working to assemble construction and implementation funds from a variety of other local, state and federal sources, so that the conceptual designs developed during the course of this project can be built and so that the residents of Sharon, Walpole and Stoughton can begin to enjoy the many health and environmental benefits associated with more effective stormwater management and attainment of surface water quality standards.

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Tables

Table 1: Top 10 prioritized Sites in Sharon, MA. The ranking of these sites was determined through collaboration between the Town, the Association and CEI.

Priority	Site ID	Site Name
1	6	Billings St
2	20	Brooke Rd.
3	9	Hixon Farm
4	10	Train Station East
5	11	Train Station West
6	7	Carbery Ave.
7	14	Gunhouse Rd.
8	19	Glenview Rd.
9	28	Beach St. Outfall
10	1	High School

Table 2: Top 10 prioritized Sites in Walpole, MA. The ranking of these sites was determined through collaboration between the Town, the Association and CEI.

Priority	Site ID	Site Name
1	4	Police Fire
2	21	Fisher School
3	12	Johnson Middle
4	14	Turner Pond
5	1	Beckets Walpole
6	13	Elm St. School
7	29	Boyden School
8	33	High School
9	46	Georgia Drive
10	9	Stergis Windows

Table 3: Top 10 prioritized Sites in Stoughton, MA. The ranking of these sites was determined through collaboration between the Town, the Association and CEI.

Priority	Site ID	Site Name
1	7	Hanson School
2	11	Gibbons School
3	12	Morton St.
4	10	Mark's Field
5	13	Rogers Drive
6	15	Jefferey Way
7	19	Middle School
8	21	Woodpecker Rd.
9	17	Manor Dr.
10	16	Whitney Ave.

Table 4: List of Prioritized BMPs used for Town surveys

BMP Name Abbreviated	BMP Name Full	Sizing Method	Low % DA Size @ 1.2"	High % DA Size @ 1.2"	Soils	Treat Meth	Maint Difficulty	Fail Risk	Cost	Bacteria Removal
PaveDiscon	Unstructured disconnection of paved areas	per VT, disconnected length = paved length, slope <5%	100.00%	200.00%	Any	Filtration/Infiltration	Low	Low	Low	Good
InfiltBasin	Infiltration Basin	Per VT, 1-2' ponding 0.5-2.0"/hr	5.00%	10.00%	A, B	Infiltration	Low	Low	Medium	Excellent
WetBasin	Wet Basin or Large Wetland	3' ponding for wetland with 1xWQv, 6' ponding for wet pond with 2xWQv	1.50%	3.50%	C, D	Settling	Low	Low	Low	Fair
BioCell	Bioretention Cell Infiltrating	Per VT, 30" media, 6-12" ponding, 6"/day k	5.00%	10.00%	A, B	Filtration/Infiltration	Medium	Low	Medium	Excellent
CompostFilter	Compost Amended Filter Strip	assume same as biocell	5.00%	10.00%	Any	Filtration/Infiltration	Low	Low	Medium	Good
BioCellUnder	Bioretention Cell with Underdrain	6" ponding + 24" media voids, could be deeper	5.00%	10.00%	C,D	Filtration/Infiltration	Medium	Low	Medium	Excellent
PocketWet	Pocket Wetland	Low is per VT, high per 30" ponding	1.50%	4.00%	C, D	Settling	Medium	Low	Medium	Fair
SandFilterSurface	Sand/Organic Filter Surface	Per VT, 2' filter depth, 1' ponding 3.5'-8.7/day k	0.55%	1.14%	Any	Filtration	Low	Low	Medium	Good
InfiltTrench	Infiltration Trench	Per VT, 3-5' stone, 0.5-2.0"/hr	5.00%	8.00%	A, B	Infiltration	Low	Medium	Medium	Excellent
GravelWet	Gravel Wetland	Per CWP, if 3' filter depth and 2' ponding, need to check this!	3.00%	5.00%	Any	Filtration	Medium	Medium	Medium	Good
TreeBox	Tree Filter Box	Per filterra, 1 per 0.25 acre, may be a bit low for 1.2"	0.36%	0.36%	Any	Filtration	Medium	Low	High	Good
SandFilterStructured	Sand/Organic Filter Surface Structured or Perimeter	Per VT, 1-2' filter depth, 6-12" ponding, 3.5-8.7'/day k	0.55%	0.86%	Any	Filtration	Low	Low	High	Good
PorousPerim	Perimeter only Porous Pavement or Pavers	1 to 5	20.00%	33.00%	Any	Filtration/Infiltration	High	High	High	Excellent
PorousPave	Porous Pavement or Pavers	1 to 1	100.00%	100.00%	Any	Filtration/Infiltration	High	High	Very High	Excellent
InfiltUnder	Underground Infiltration Structures	Per VT,2-4' deep chambers, 0.5-	2.50%	5.00%	A, B	Infiltration	High	High	High	Excellent
SandFilterUnder	Sand/Organic Filter Underground	Same as surface	0.55%	1.14%	Any	Filtration	High	Medium	High	Good
LeachCB	Leaching Catch Basin	Derived from VT, 50 CF each, need 20-22/Ac	2.50%	2.50%	A, B	Infiltration	Medium	High	High	Excellent
BMPs for Rooftop Flows										
DryWell	Structured downspout disconnect to Dry Well or French Drain or Stormwater Planter	50 cf storage / 4'x4', 500-1200 SF per unit, 36-87 units per acre	2.50%	2.50%	Any	Infiltration	Low	Medium	Medium	Excellent
RoofDiscon	Unstructured downspout disconnect to lawn or rain barrel	per VT, disconnection length should equal roof length, slope <5%	100.00%	200.00%	Any	Filtration/Infiltration	Low	Low	Low	Good
RainGarden	Rain Garden	Per VT, 6" ponding, 0.5-2.0"/hr	15.00%	20.00%	A, B	Infiltration	Medium	Low	Medium	Excellent
Pre Treatment BMPs										
GrassStrip										
GravelDiaphragm										
GrassChannel										
Forebay										
GritChamber										
MulchLayer										
Other										
None										

Table 5: Water Quality data collected from outfalls or discharge points at the top 3 locations in each town.

Date	Sample ID	Time	Bacteria	Ammonia	Surfactants	Temperature
5/4/2011	Billings 1	5:30 PM	686.7	0.017	0.25	14.0
5/19/2011	Billings 1	12:05 PM	186.0	0.000	0.25	12.0
5/4/2011	Brooke 1	5:39 PM	275.5	0.317	0.00	16.5
5/19/2011	Brooke 1	12:15 PM	365.4	0.041	0.25	14.0
5/4/2011	Fisher 1	4:19 PM	6867.0	0.021	0.00	15.0
5/19/2011	Fisher 1	10:57 AM	52.1	0.038	0.25	13.0
5/4/2011	Fisher 2	4:23 PM	248.1	0.086	0.00	14.5
5/19/2011	Fisher 2	10:53 AM	285.1	0.053	0.25	12.0
5/4/2011	Fisher 3	4:26 PM	21.6	0.154	0.50	17.0
5/19/2011	Fisher 3	10:51 AM	29.8	0.000	0.00	15.0
5/4/2011	Hixon 1	5:47 PM	248.1	0.291	0.00	17.0
5/19/2011	Hixon 1	12:26 PM	325.5	0.109	0.25	13.5
5/4/2011	Johnson 1	4:38 PM	770.1	0.241	0.25	17.0
5/19/2011	Johnson 1	11:10 AM	107.6	0.067	0.00	13.5
5/4/2011	Johnson 2	4:42 PM	980.4	0.158	0.25	14.5
5/19/2011	Johnson 2	11:15 AM	>24196	0.093	0.25	14.0
5/4/2011	PF1	5:02 PM	4352.0	0.063	0.00	19.5
5/19/2011	PF1	11:40 AM	920.8	0.152	0.00	16.0
5/4/2011	Turner 1	4:49 PM	67.7	0.000	0.00	14.5
5/19/2011	Turner 1	11:28 AM	22.3	0.032	0.00	14.0
5/4/2011	Turner 2	4:55 PM	201.4	0.063	0.25	14.5
5/19/2011	Turner 2	11:33 AM	39.9	0.071	0.25	14.0
6/9/2011	Gibbons Outfall	9:52 AM	15531.0	2.631	0.25	23.5
6/22/2011	Gibbons Outfall	1:17 PM	2481.0	1.161	0.25	24.0
6/9/2011	Hanson Outfall	10:16 AM	1986.3	2.337	0.00	20.0
6/22/2011	Hanson Outfall	1:46 PM	2755.0	0.617	0.25	23.5
6/9/2011	Marks Field	10:03 AM	40.4	2.229	0.00	25.0
6/22/2011	Marks Field	1:32 PM	727.0	0.763	0.25	23.5

		Bacteria	Ammonia	Surfactants	Temperature
Maximum		>24196	2.229	0.50	25.0
Minimum		13.5	0.000	0.00	12.0
Average		2313.2	0.467	0.13	16.5

Table 6: Water quality data collected from receiving waters at each of the top 3 locations in each town.

Date	Sample ID	Time	Bacteria	Ammonia	Surfactants	Temperature
5/4/2011	Billings Brook	5:26 PM	44.1	0.063	0.00	16.5
5/19/2011	Billings Brook	12:03 PM	517.2	0.000	0.00	13.5
5/4/2011	Fisher Pond	4:32 PM	>2419.6	0.196	0.00	17.5
5/19/2011	Fisher Pond	11:01 AM	224.7	0.040	0.00	17.0
5/4/2011	Hixon Stream	5:49 PM	920.8	0.035	0.00	16.5
5/19/2011	Hixon Stream	12:30 PM	>2419.6	0.072	0.00	14.0
5/4/2011	Johnson Stream	4:39 PM	35.5	0.000	0.00	18.5
5/19/2011	Johnson Stream	11:14 AM	36.4	0.027	0.00	12.5
5/4/2011	SPB016	5:05 PM	1299.7	0.000	0.00	17.0
5/19/2011	SPB016	11:44 AM	53.7	0.000	0.00	14.5
5/4/2011	Turner Pond	4:52 PM	13.5	0.000	0.00	18.0
5/19/2011	Turner Pond	11:30 AM	27.9	0.048	0.25	14.0
6/9/2011	Gibbons Stream	9:56 AM	>2419.6	1.149	0.00	20.0
6/22/2011	Gibbons Stream	1:19 PM	12033.0	1.501	0.50	16.5
6/9/2011	Hanson Stream	10:19 AM	435.2	0.131	0.00	18.5
6/22/2011	Hanson Stream	1:49 PM	980.4	0.061	0.25	21.0
	Maximum		12033	1.501	0.50	21.0
	Minimum		13.5	0.000	0.00	12.5
	Average		1492.4	0.208	0.06	16.6

Table 7: Summary table of data produced for this project by CEI.

Town ***Sharon, MA***

Site	BMP	Area of BMP	1" WQv	WQv Treated	% 1" WQv treated	Construction Cost	Annual O/M Cost
Billings St	Extended Detention Wetland	8000	26,532	32,000	120.61%	$278,350	$1,085
Brook Rd.	Pocket Wetland	2500	3,608	3,750	103.94%	$75,500	$1,085
Hixon Farm	Bioretention Cell	2000	11,984	2,800	23.36%	$93,100	$1,050

Town ***Walpole, MA***

Site	BMP	Area of BMP	1" WQv	WQv Treated	% 1" WQv treated	Construction Cost	Annual O/M Cost
Police/Fire	Bioretention Cell w/underdrains	1570	8393	2669	31.80%	$98,100	$1,050
Fisher School							
Site 1	Pocket Wetland	3250	2938	3250	110.62%	$92,500	$1,085
Site 2	Vegetated Wetland	4750	14242	14250	100.06%	$210,750	$1,085
Site 3	Pocket Wetland	2750	5527	5500	99.51%	$83,500	$1,085
Johnson Middle							
Site 1	Infiltration Basin	2600	10543	7800	73.98%	$84,500	$1,325
Site 2	Bioretention Cell w/underdrains	300	171	330	192.98%	$17,000	$1,050

Town ***Stoughton, MA***

Site	BMP	Area of BMP	1" WQv	WQv Treated	% 1" WQv treated	Construction Cost	Annual O/M Cost
Hanson School							
Site 1	Bioretention Cell	3000	7275	5700	78.35%	$128,975	$1,050
Site 2	Infiltration Trench	2000	4917	2400	48.81%	$69,350	$550
Site 3	Infiltration Trench	650	2238	780	34.85%	$12,450	$550
Gibbons School							
Site 1	Infiltration Basin	2000	3746	4000	106.78%	$46,000	$1,325
Site 2	Bioretention Cell	2500	4127	4750	115.10%	$94,850	$1,050
Site 3	Bioretention Cell	1500	8222	2850	34.66%	$65,000	$1,050
Mark's Field	Infiltration Basin	1500	4136	4500	108.80%	$51,500	$1,325

Figures

Figure 1: Map of entire study area in relation to the eastern portion of the state of Massachusetts.

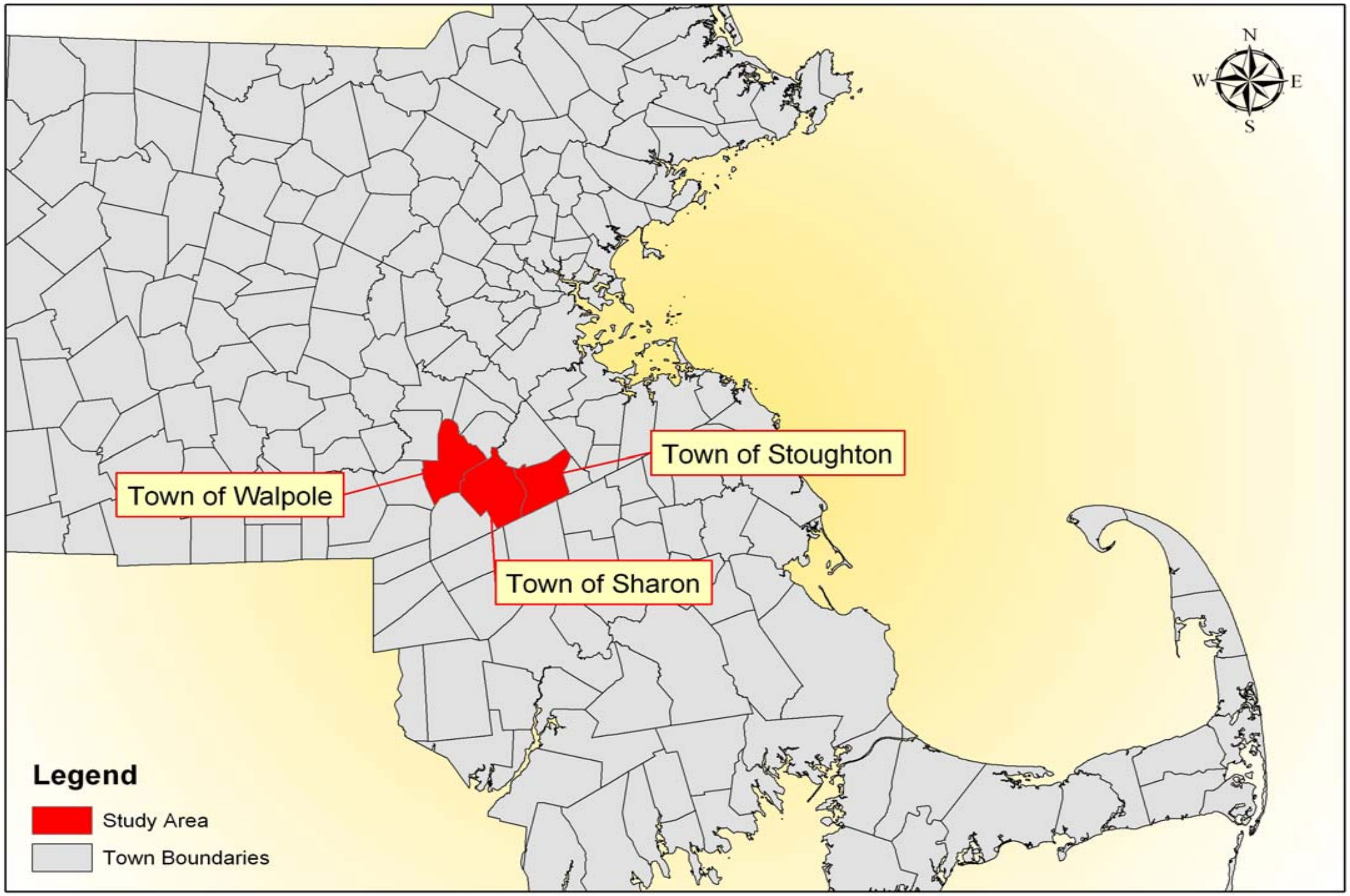

Figure 2: Individual study area for Sharon, MA.

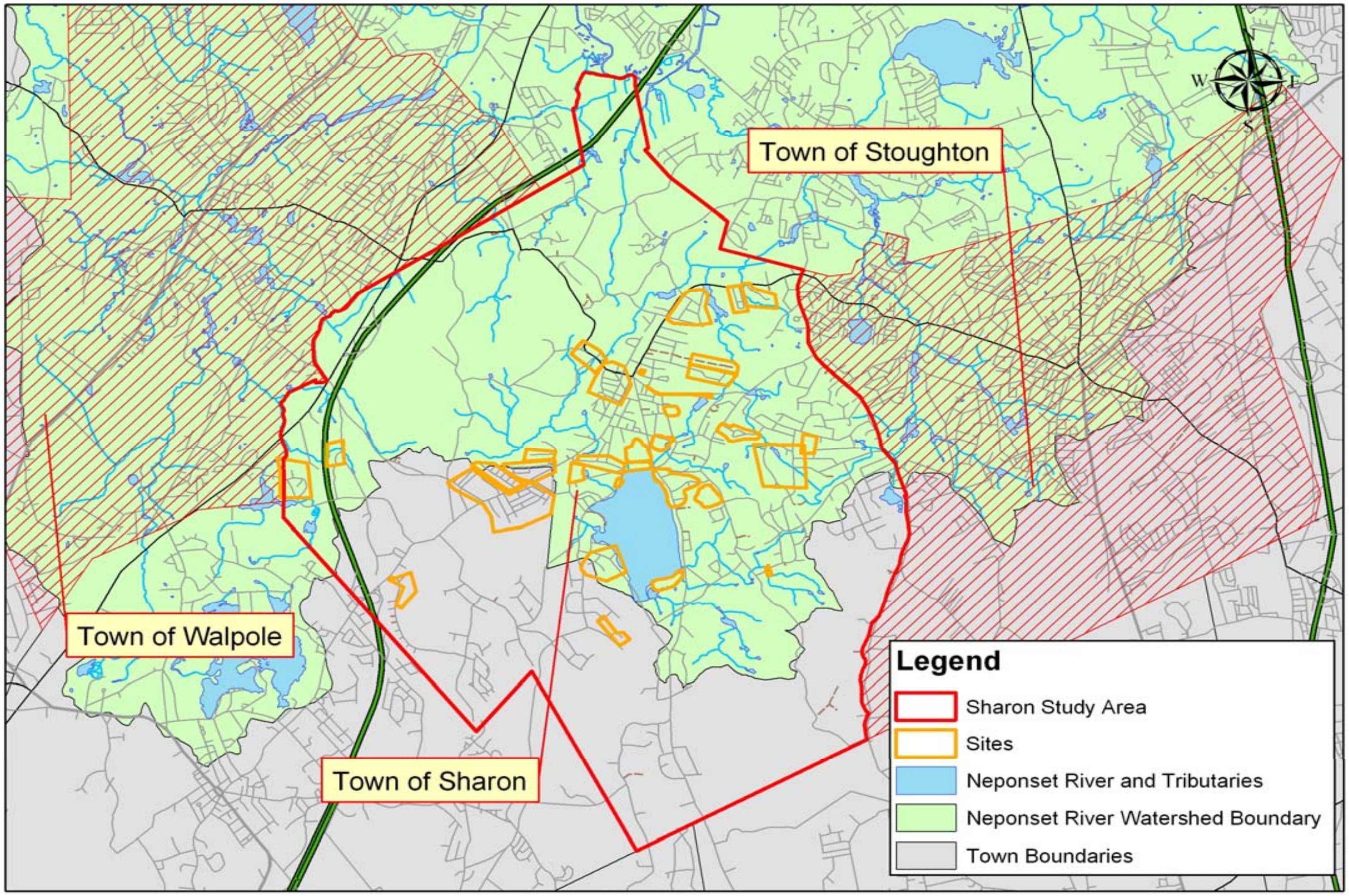

Figure 3: Individual study area for Walpole, MA.

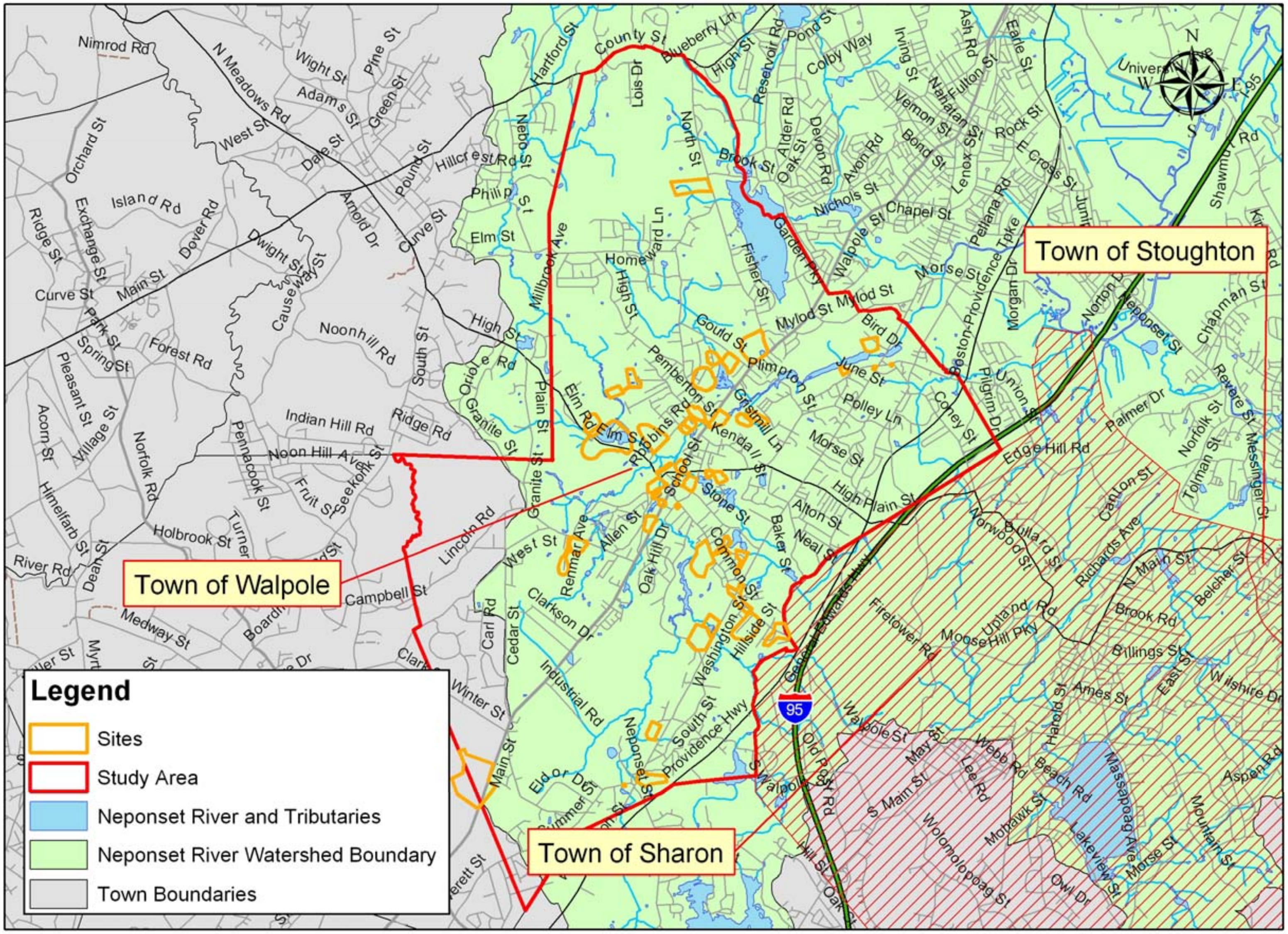

Figure 4: Individual study area for Stoughton, MA.

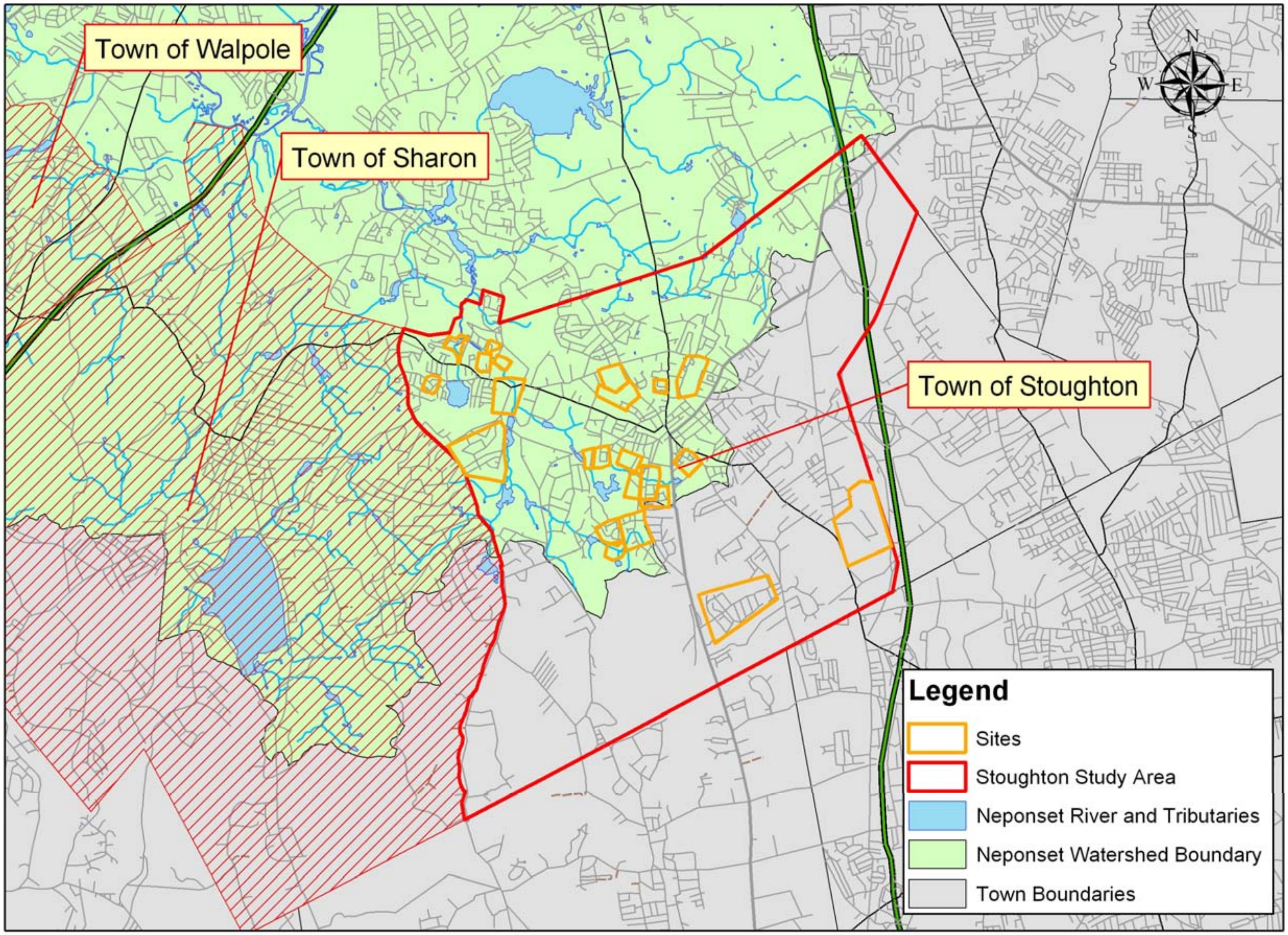

Figure 5: Top rated site along Billings St. in Sharon, MA.

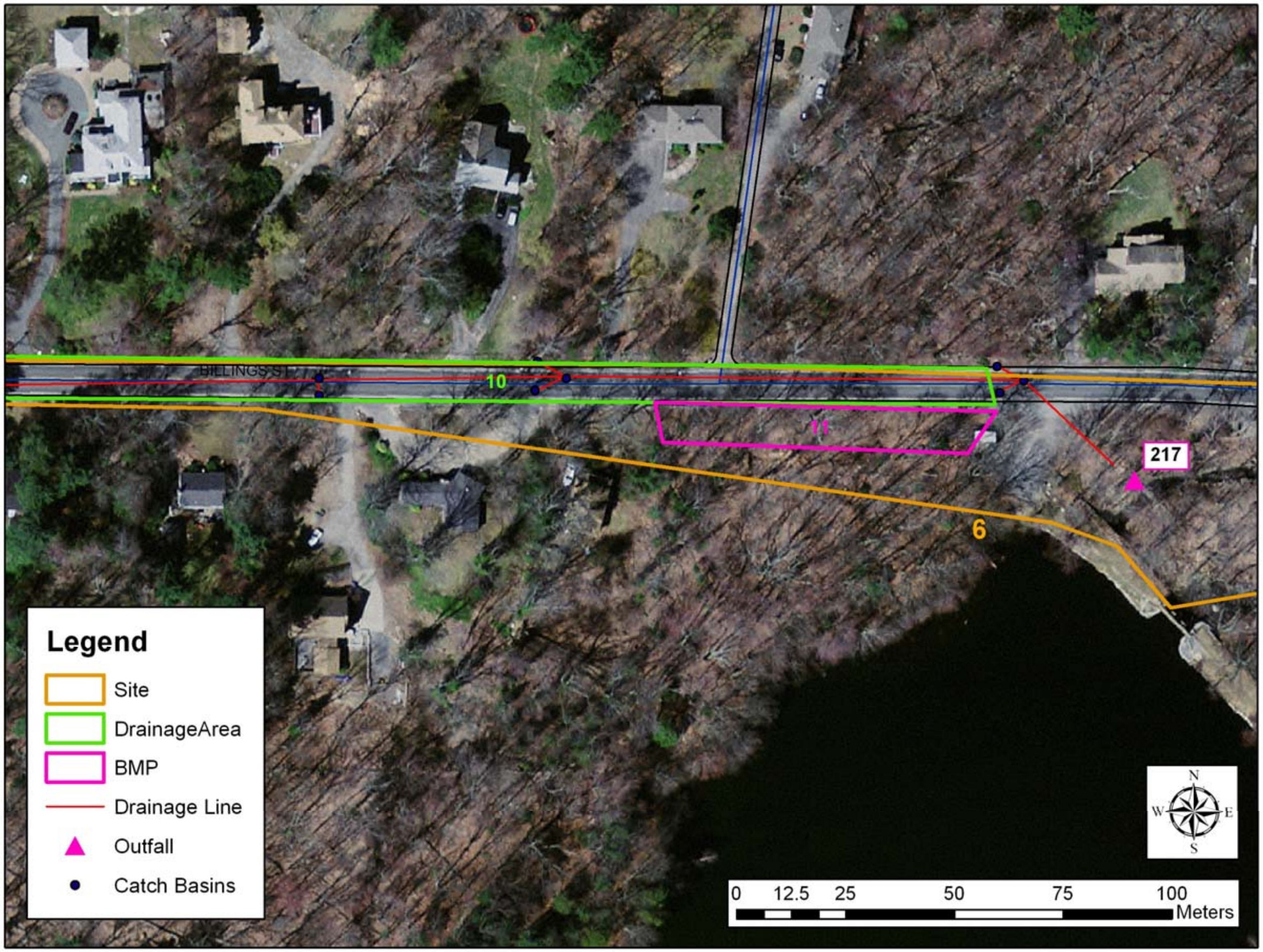

Figure 6: Second highest rated site in Sharon, MA at the end of Brook Rd.

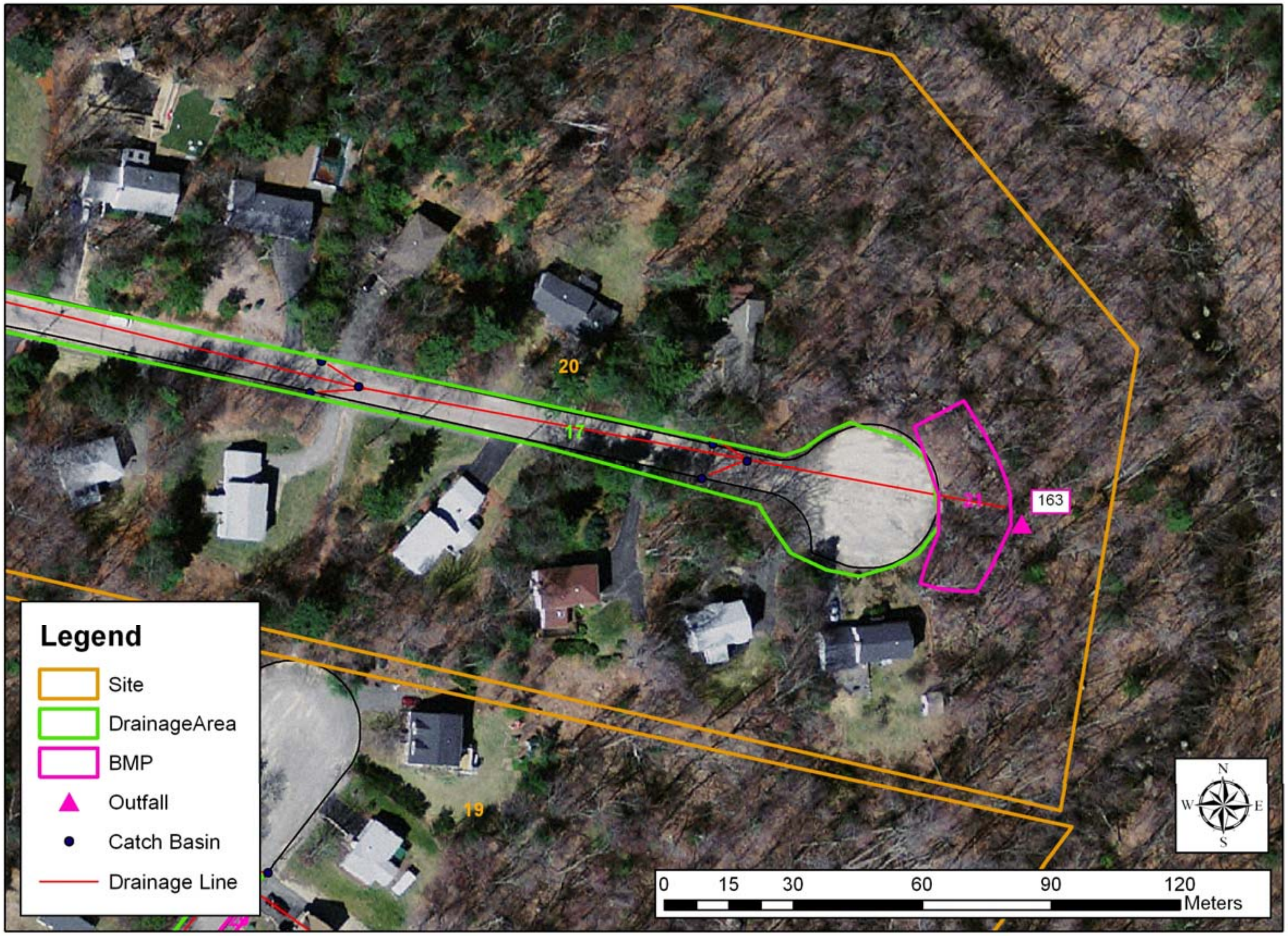

Figure 7: Third highest rated site in Sharon, MA at Hixon Farm.

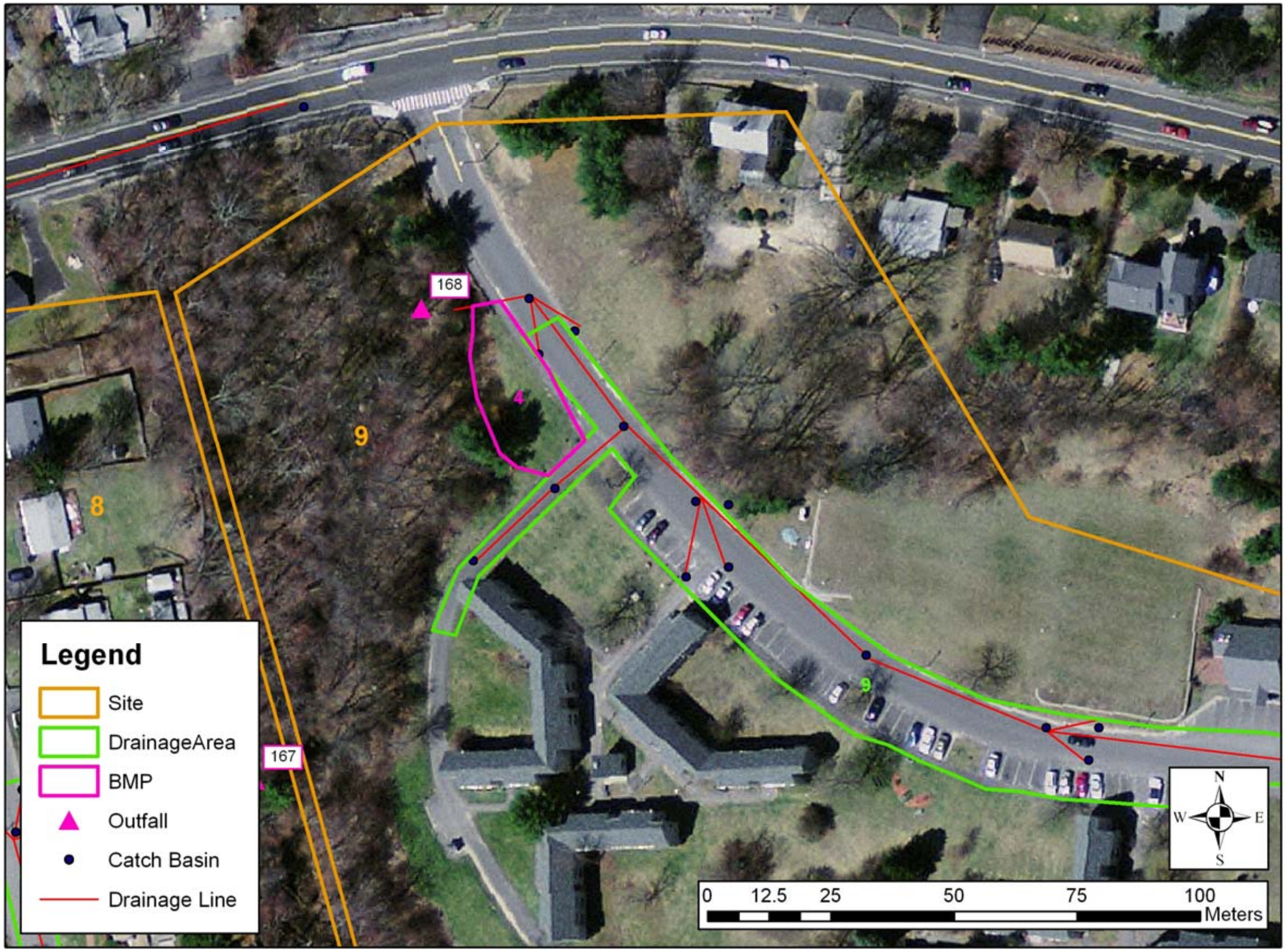

Figure 8: Top rated site in Walpole, MA. Parking lot behind the police and fire stations.

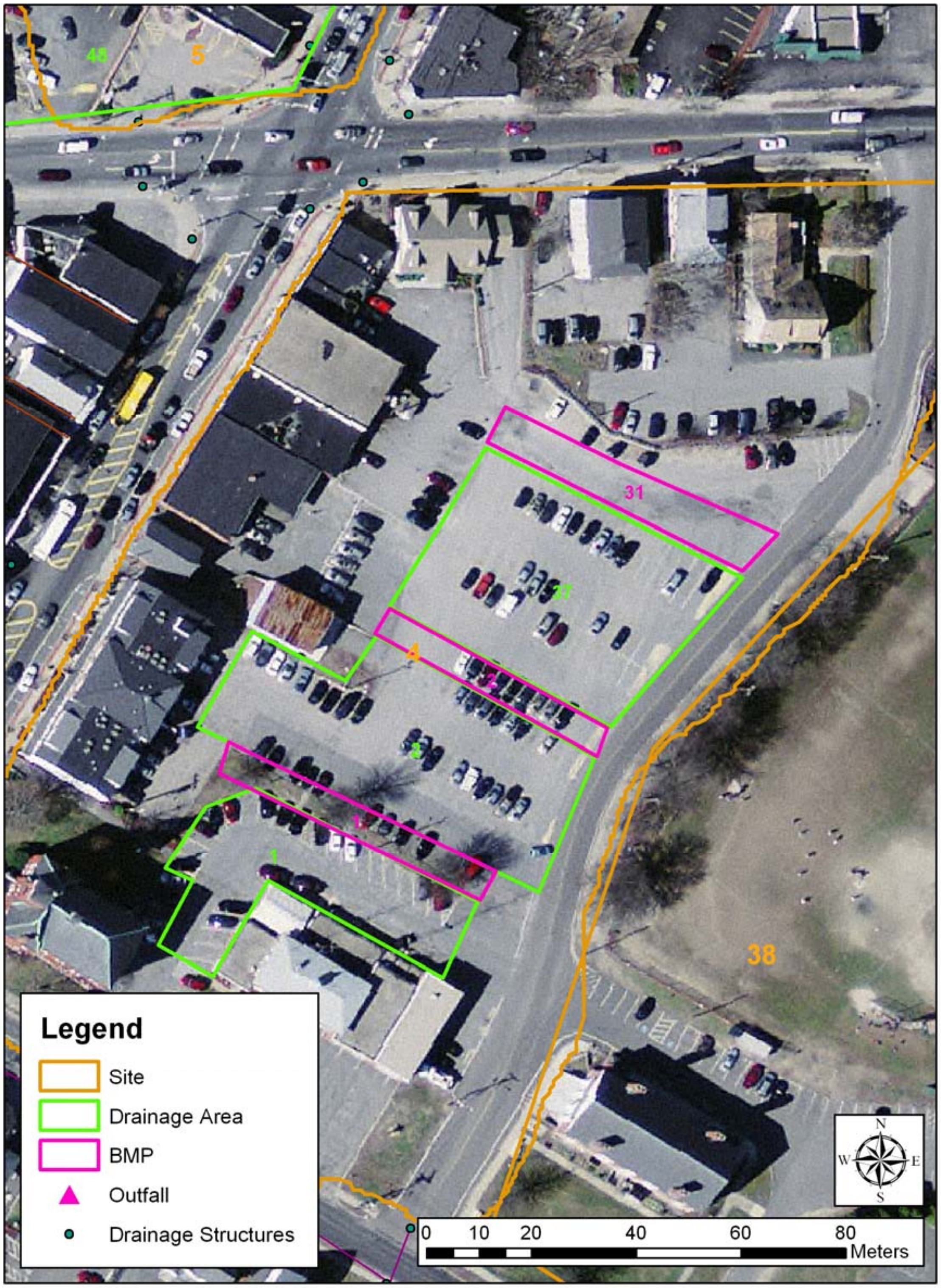

Figure 9: Second highest rated site in Walpole, MA at the Fisher Elementary School.

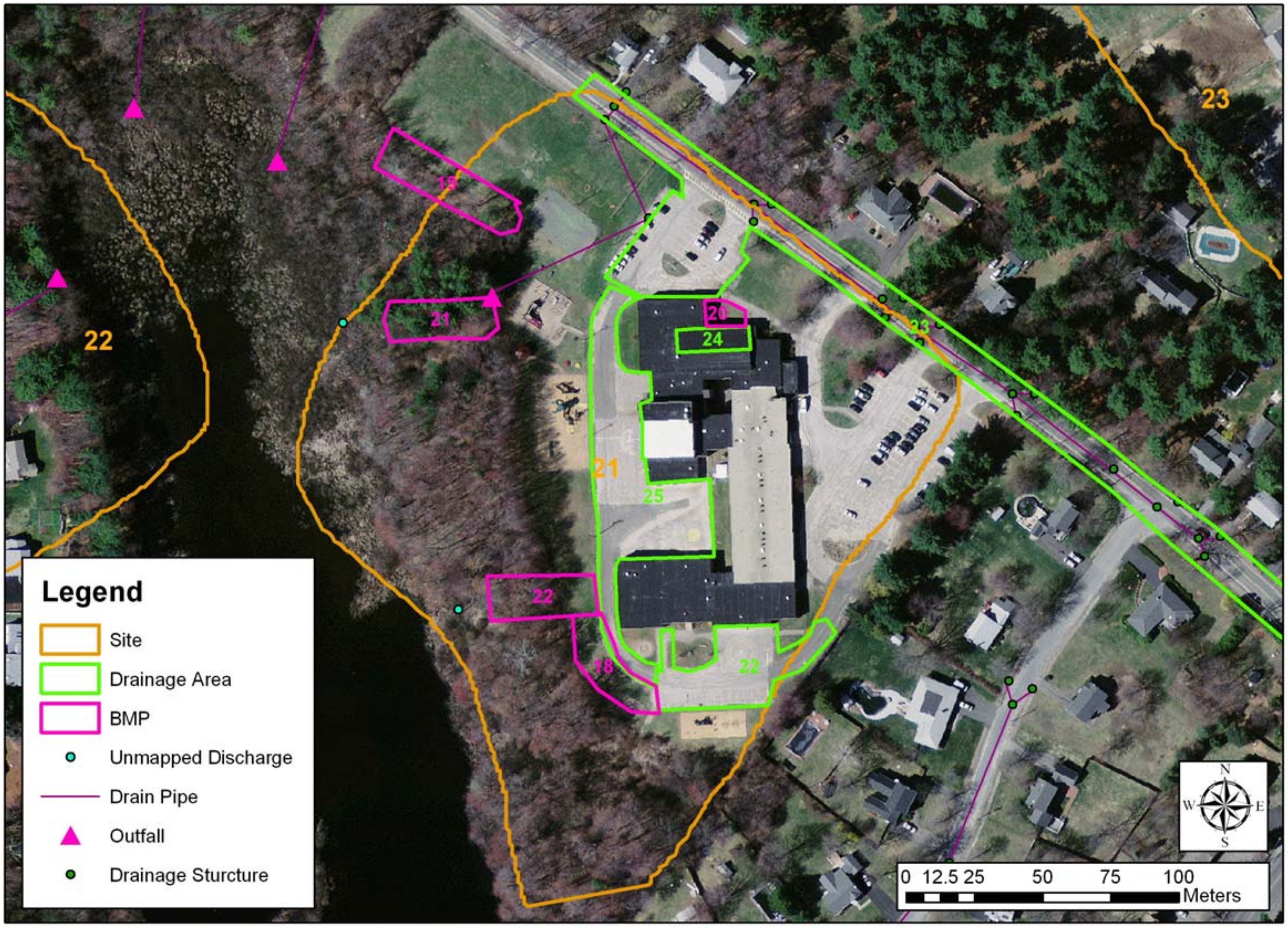

Figure 10: Third highest rated site near the Johnson Middle School in Walpole, MA.

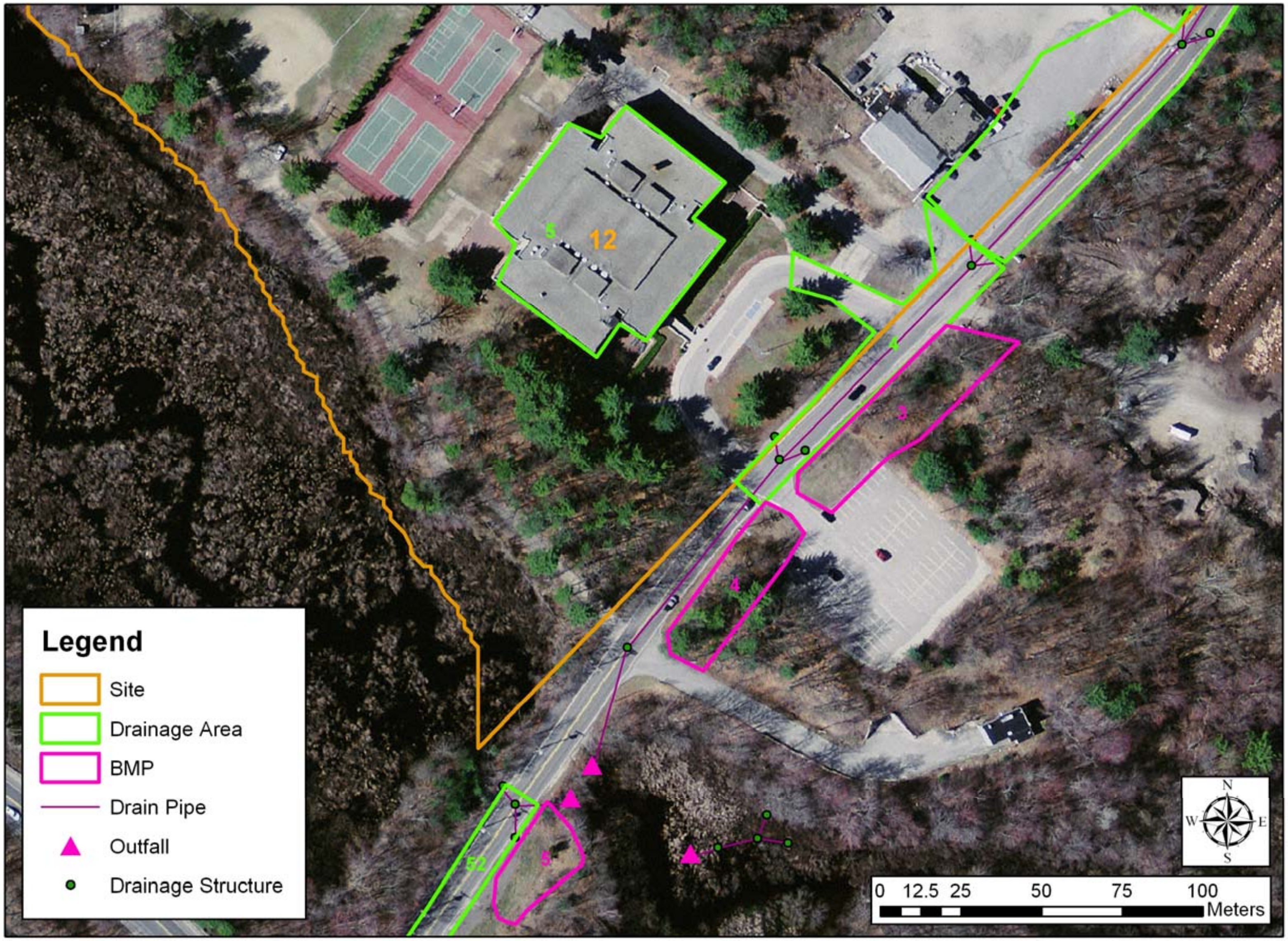

Figure 11: First image depicting recommended BMPs at the top rated site adjacent to the Hanson Elementary School in Stoughton, MA.

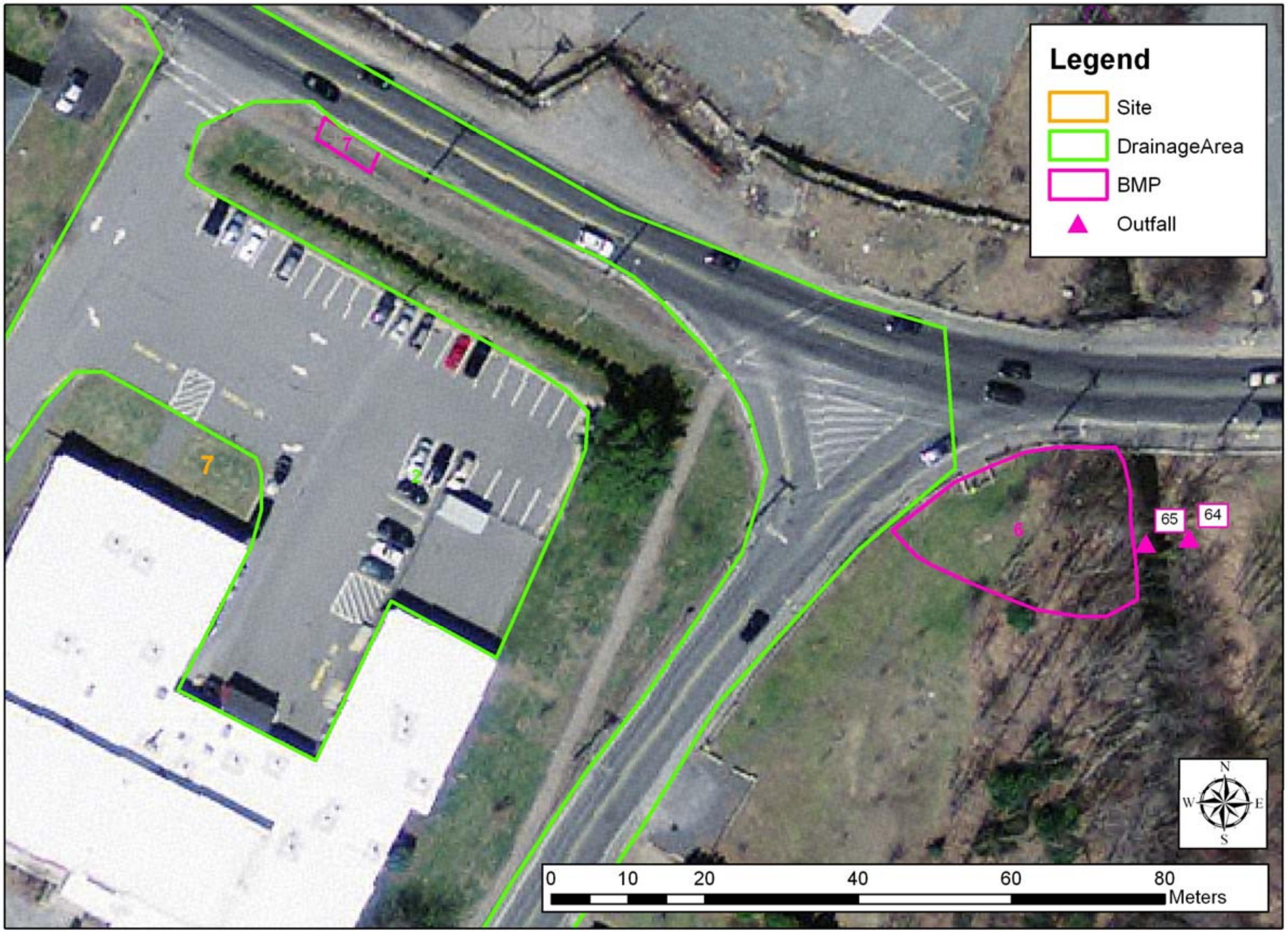

Figure 12: Second image depicting potential locations for BMPs adjacent to the Hanson Elementary School in Stoughton, MA.

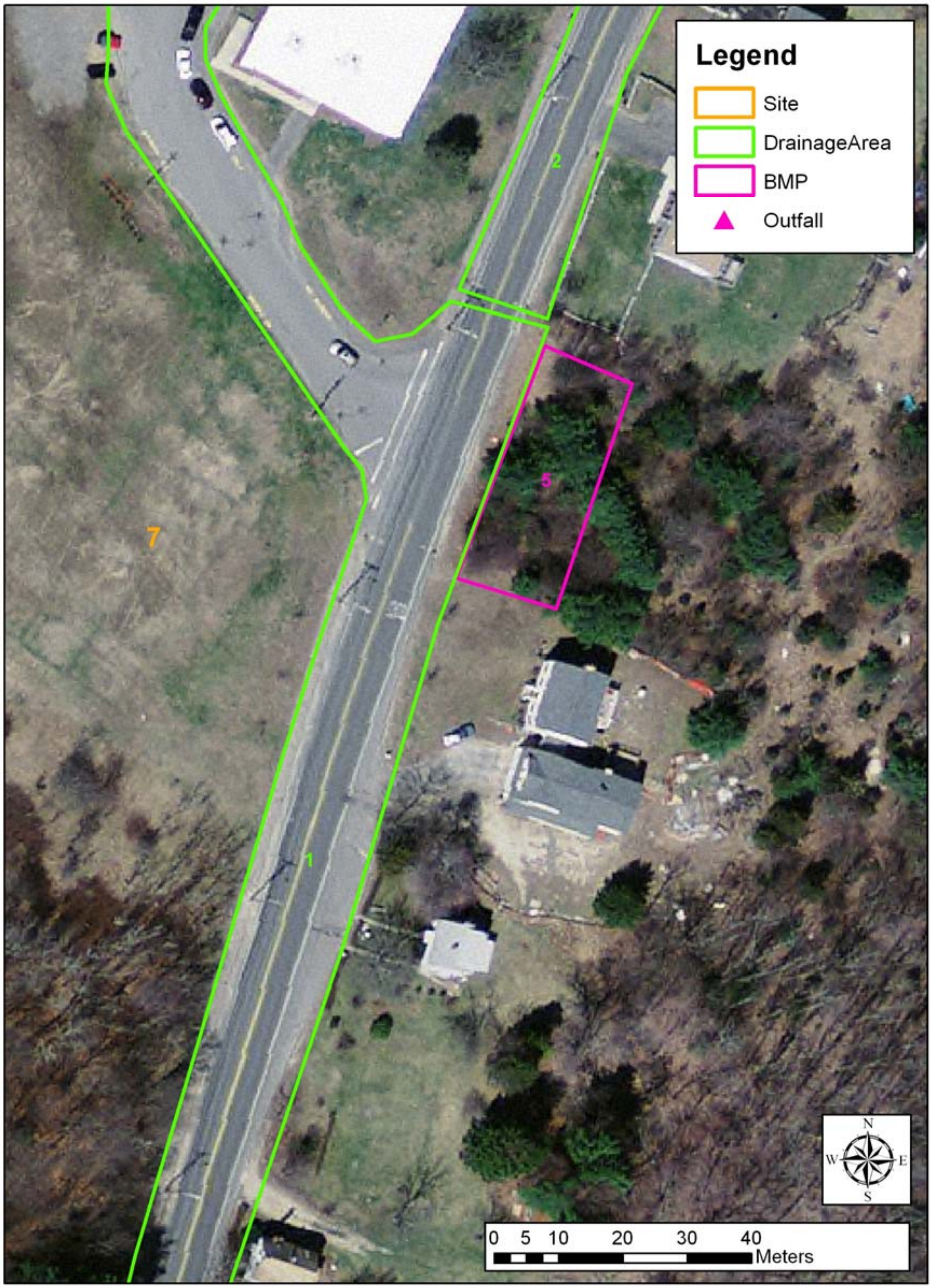

Figure 13: Potential locations for BMPs near the Gibbons Elementary School, the second highest priority site in Stoughton, MA.

Figure 14: Additional BMP recommendations along Morton St in Stoughton, MA. This site would be combined with the Gibbons Elementary School site into one project.

Figure 15: Third highest rated site for BMP retrofits adjacent to Mark's Field in Stoughton, MA.